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**COMPARATIVE TESTS OF THE STRENGTH AND TIGHTNESS OF
COMMERCIAL FLUSH RIVETS OF ONE TYPE AND NACA
FLUSH RIVETS IN MACHINE-COUNTERSUNK
AND COUNTERPUNCHED JOINTS**

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RESTRICTED BULLETIN

COMPARATIVE TESTS OF THE STRENGTH AND TIGHTNESS OF
COMMERCIAL FLUSH RIVETS OF ONE TYPE AND NACA
FLUSH RIVETS IN MACHINE-COUNTERSUNK
AND COUNTERPUNCHED JOINTS

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SUMMARY

An investigation was conducted to compare the strength and tightness of machine-countersunk flush-riveted joints assembled with NACA flush rivets and one type of commercial flush rivet and also to compare the strength and tightness of counterpunched flush-riveted joints assembled with the same types of rivet. The results of the investigation are presented in the form of load-displacement curves, which indicate that the NACA flush-riveted joints tended to be somewhat stronger and tighter than the corresponding commercial flush-riveted joints. The test results also show that both the commercial and the NACA counterpunched flush-rivet specimens had considerably greater strength than the machine-countersunk specimens of corresponding sheet thickness.

INTRODUCTION

The studies of tightness and flushness of machine-countersunk flush rivets for aircraft described in references 1 to 3 indicated that the NACA flush-riveting procedure produced the tightest joints for the types of flush riveting investigated. As a result of this conclusion, an investigation was conducted to determine the comparative tightness of machine-countersunk flush-riveted joints assembled with NACA flush rivets and commercial flush rivets of one type and also the comparative tightness of counterpunched flush-riveted joints assembled with the same types of rivet. Thirty-six specimens, prepared by an airplane manufacturer, were tested in the present investigation.

SPECIMENS

Machine countersunk.- Each machine-countersunk specimen consisted of two sheets of 24S-T aluminum alloy assembled in the form of a lap joint with two aluminum-alloy rivets; as shown in figure 1. The $\frac{1}{8}$ -inch-diameter rivets were of Al7S-T and the $\frac{1}{4}$ -inch-diameter rivets, of 17S-T aluminum alloy.

The particular commercial flush-riveting procedure used corresponds to riveting method C of references 1 and 2. The rivet hole in the upper sheet was machine-countersunk for a 78° countersunk-head rivet, as shown in figure 2(a). Drill sizes and angle of countersink were not specified by the manufacturer. A 78° countersunk-head rivet was inserted in the rivet hole, and the manufactured head was driven with a vibrating gun while the shank end was bucked with a bar.

The NACA flush-riveting procedure is riveting method E of references 1 and 2. The NACA procedure involved the same preparation of the rivet hole as the commercial procedure, but a $\frac{1}{8}$ -inch-diameter round-head (AN430) rivet or a $\frac{1}{4}$ -inch-diameter brazier-head (AN456) rivet was inserted from the back of the joint, and the manufactured head was driven with a vibrating gun while the shank end was bucked into the countersunk hole with a bar, as shown in figure 2(b). The portion of the formed head that protruded above the skin surface was removed with a flush-rivet milling tool similar to the one described in reference 4.

Counterpunched.- The counterpunched specimens were of the same form as the machine-countersunk specimens, except for preparation of the rivet holes. The lower sheets were machine-countersunk and the upper sheets were counterpunched into the lower sheets as shown in figure 3.

Remarks.- In only one of the nine $\frac{1}{4}$ -inch-diameter rivet specimens assembled with either machine-countersunk or counterpunched NACA flush rivets were the rivets

driven sufficiently to fill the countersunk hole completely. Figure 4 shows the gaps around the incompletely driven heads of four representative specimens.

TEST PROCEDURE

Load was applied to the specimens through Templin grips with a hydraulic testing machine accurate to within one-half of 1 percent. Displacements of one sheet relative to the other were measured on the edges of the sheets at the rivet line by means of two 18-power optical micrometers. Both the displacement under load and the permanent displacement remaining after removal of load were measured for successively increasing loads until failure occurred.

RESULTS AND CONCLUSIONS

Typical specimens after failure are shown in figure 5. All the machine-countersunk specimens failed by shear of the rivets. The counterpunched specimens failed either by tension failure of the upper sheet across the rivet line or by shear of the rivets, except for the $\frac{1}{4}$ -inch-diameter NACA counterpunched rivet specimens, which failed by tension of the rivets. The manufactured brazier heads of the rivets sheared parallel to the axes of the rivets, probably because of the tensile load imposed on the rivets by the tendency of the dimple in the upper sheet to ride up the side of the countersunk hole in the lower sheet.

The results of the tests are presented in figures 6 to 9 as curves of load plotted against displacement under load and curves of load plotted against permanent displacement after removal of load. The specimen numbers on the curves are given in order to permit proper association of the curves of displacement under load with the curves of permanent displacement. From these curves the following conclusions may be drawn concerning the NACA flush rivets and the commercial flush rivets of the type tested in the investigation:

1. When a machine-countersunk 0.040- or 0.051-inch-thick sheet of 24S-T aluminum alloy was riveted to a 0.125-inch-thick sheet with $\frac{1}{8}$ -inch-diameter rivets of Al7S-T aluminum alloy, there appeared to be, within the normal scatter of data, no difference between the maximum strength or the tightness of the joints as shown by the load-displacement curve for NACA and commercial flush rivets. (See fig. 6.) When a machine-countersunk 0.081- or 0.091-inch-thick sheet was riveted to a 0.125-inch-thick sheet with $\frac{1}{4}$ -inch-diameter rivets of 17S-T aluminum alloy, the strength and tightness of the joints were somewhat better for the NACA rivets than for the commercial rivets. (See fig. 7.)

2. When a counterpunched 0.040-inch-thick sheet was riveted to a 0.125-inch-thick sheet with $\frac{1}{8}$ -inch-diameter rivets of Al7S-T aluminum alloy, the average maximum strength was higher and the average tightness was better for the NACA rivets than for the commercial rivets, although one NACA flush-rivet specimen failed at a considerably lower load than the other NACA rivet specimens in the group. (See fig. 8.) When a counterpunched 0.081-inch-thick sheet was riveted to a 0.125-inch-thick sheet with $\frac{1}{4}$ -inch-diameter rivets of 17S-T aluminum alloy, the NACA rivets were slightly stronger and tighter at higher loads than the commercial rivets. (See fig. 9.)

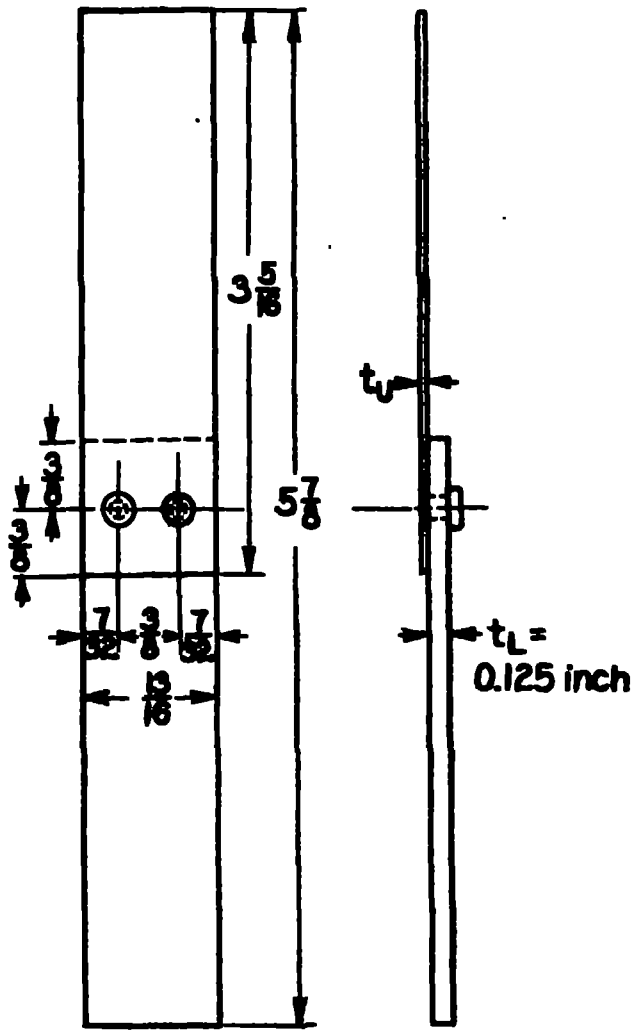
3. Both the commercial and the NACA counterpunched flush-rivet specimens had higher ultimate loads than the machine-countersunk specimens of corresponding sheet thickness - approximately 60 percent higher for the $\frac{1}{8}$ -inch-diameter rivet specimens and 38 percent higher for the $\frac{1}{4}$ -inch-diameter rivet specimens.

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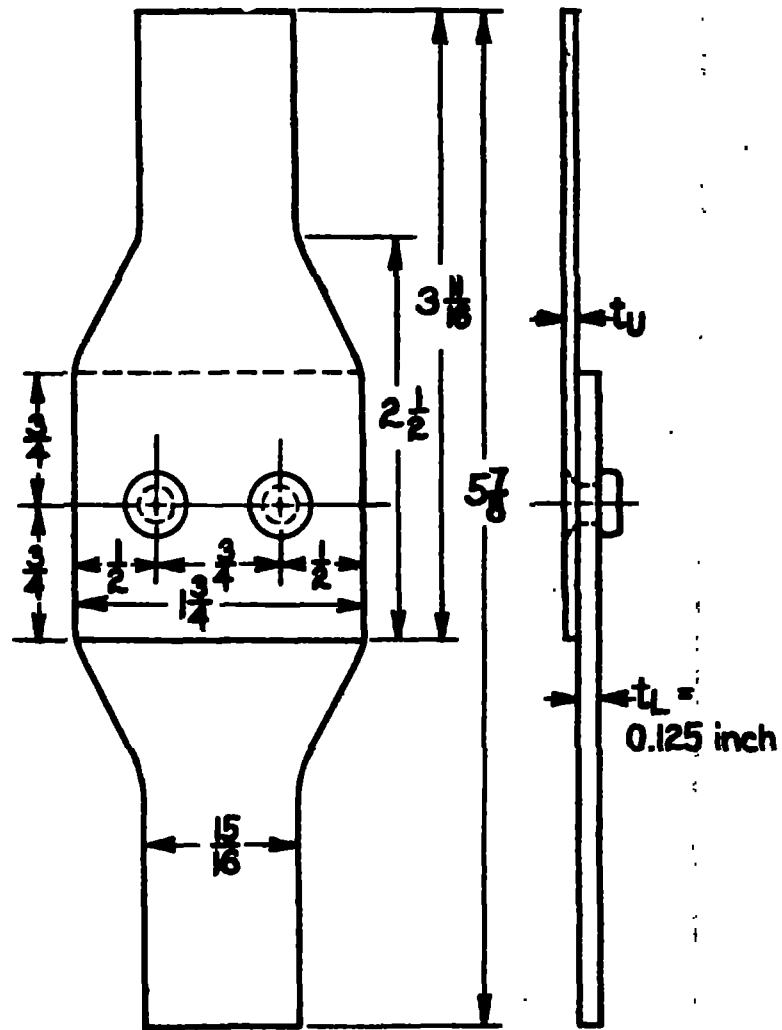
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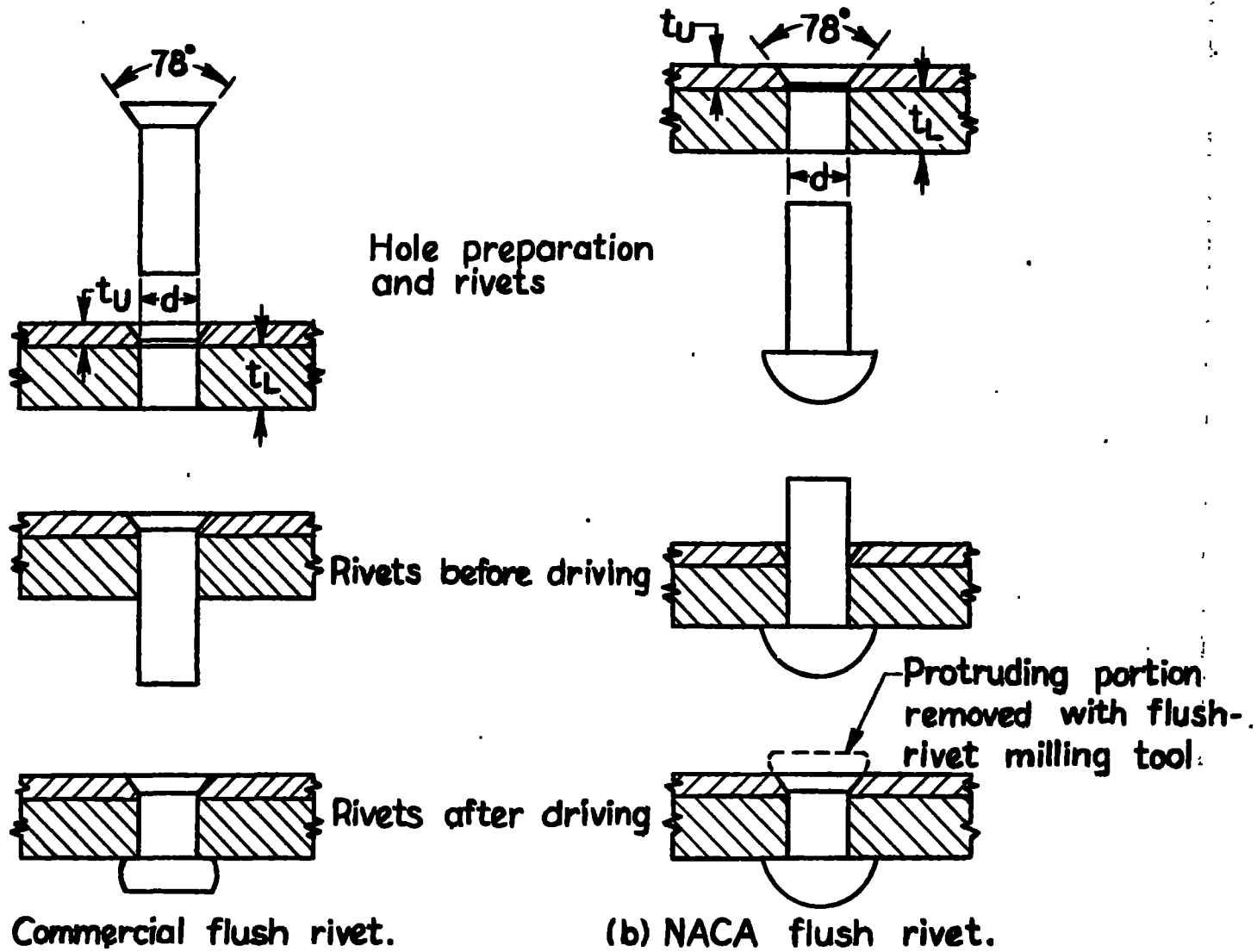


(a) $\frac{1}{8}$ -inch-diameter rivet specimen.



(b) $\frac{1}{4}$ -inch-diameter rivet specimen.

Figure 1. - Test specimens.



(a) Commercial flush rivet.

(b) NACA flush rivet.

Figure 2.~Machine-countersunk flush-riveted joints.

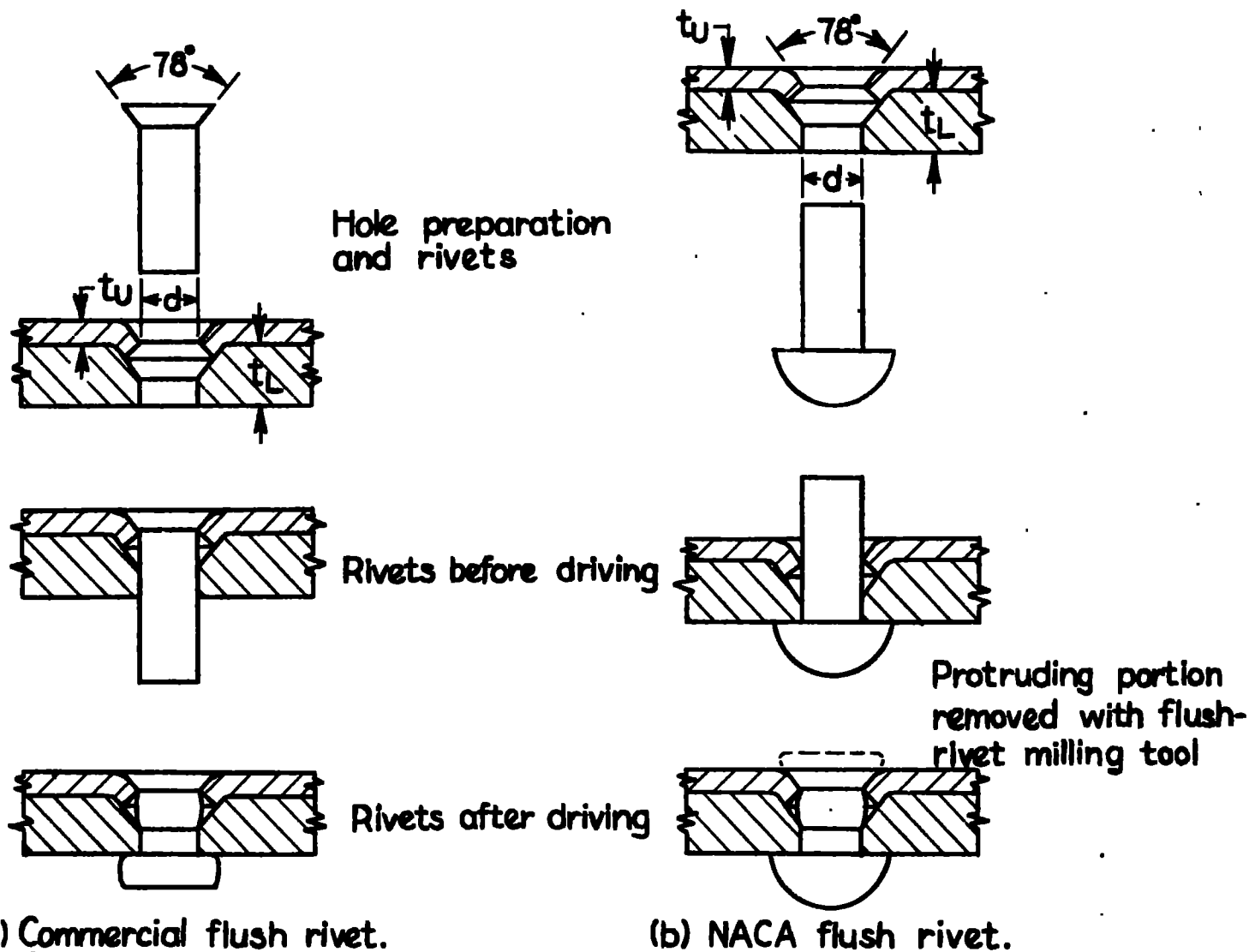


Figure 3.-Counterpunched flush-riveted joints.

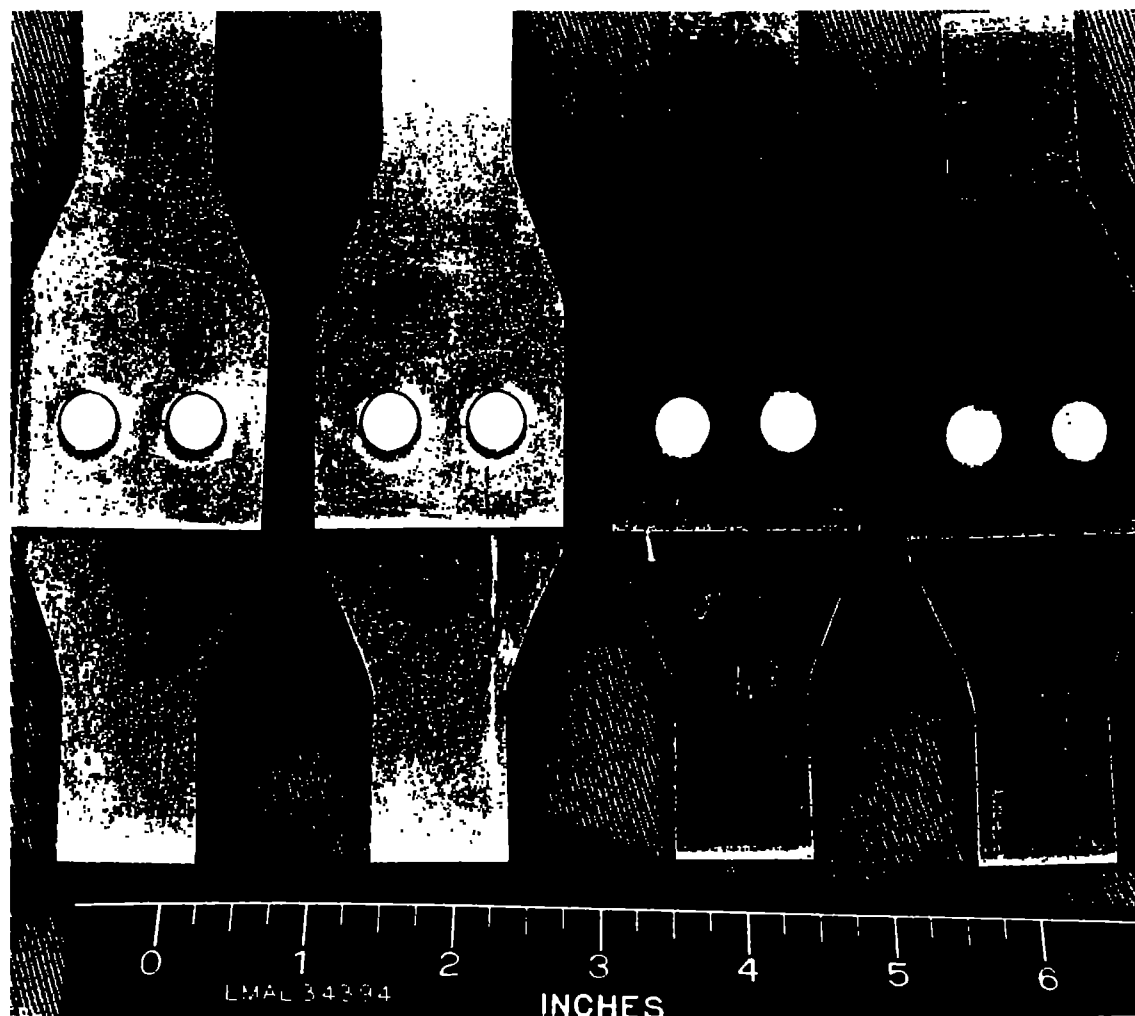
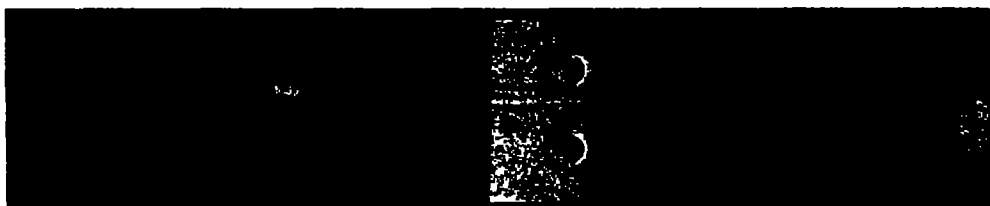


Figure 4.- Specimens assembled by the NACA flush-riveting procedures with $\frac{1}{4}$ -inch-diameter rivets showing insufficient driving.



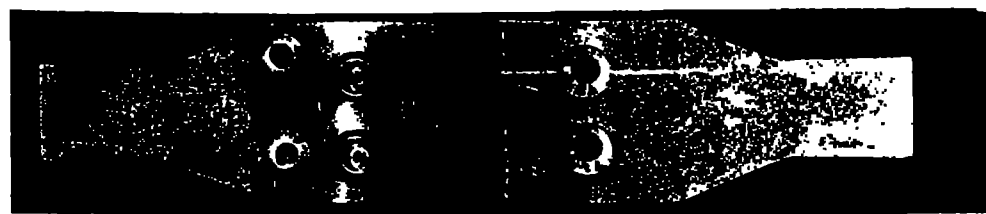
(a) Specimen with NACA machine-countersunk rivets showing shear failure of rivets.



(b) Specimen with commercial counterpunched rivets showing tension failure of sheet.



(c) Specimen with commercial counterpunched rivets showing shear failure of rivets.



(d) Specimen with NACA counterpunched rivets showing tension failure of rivets (shear failure of manufactured brazier heads).

Figure 5.- Typical $\frac{1}{4}$ -inch-diameter rivet specimens after failure.

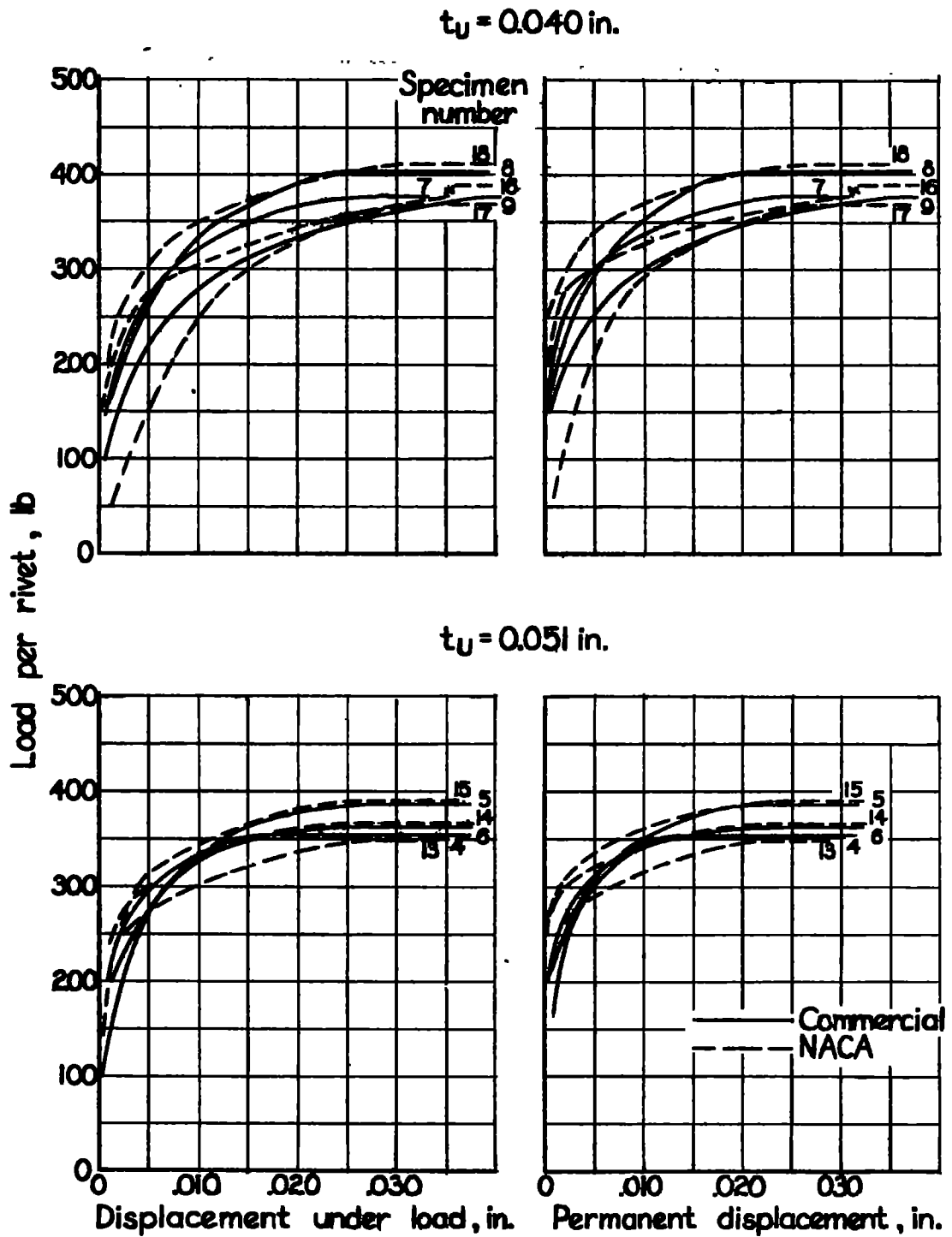


Figure 6.~ Load-displacement curves for commercial and NACA machine-countersunk flush-rivet specimens, $d = \frac{1}{8}$ in.

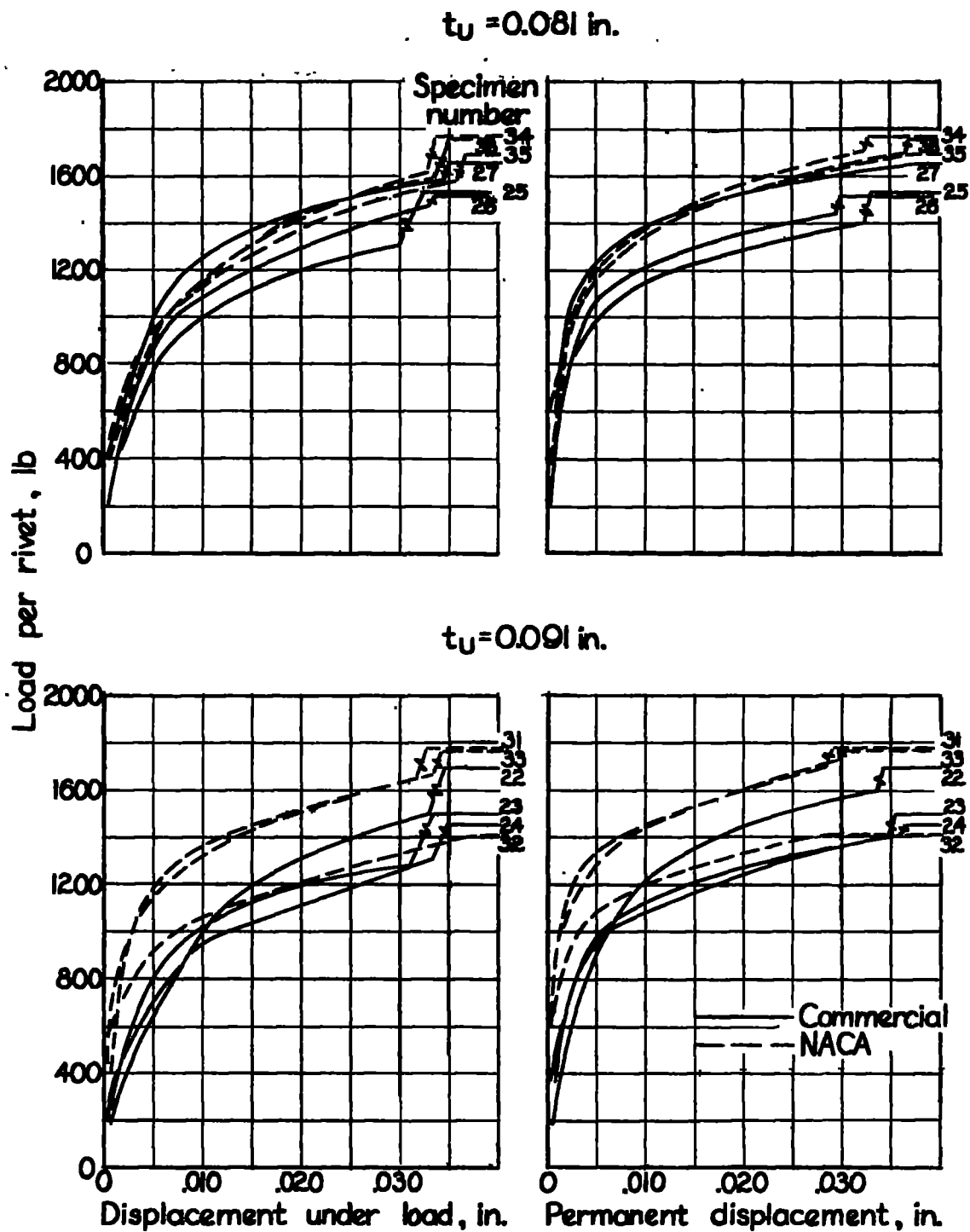


Figure 7. ~ Load-displacement curves for commercial and NACA machine-countersunk flush-rivet specimens, $d = \frac{1}{4}$ in.

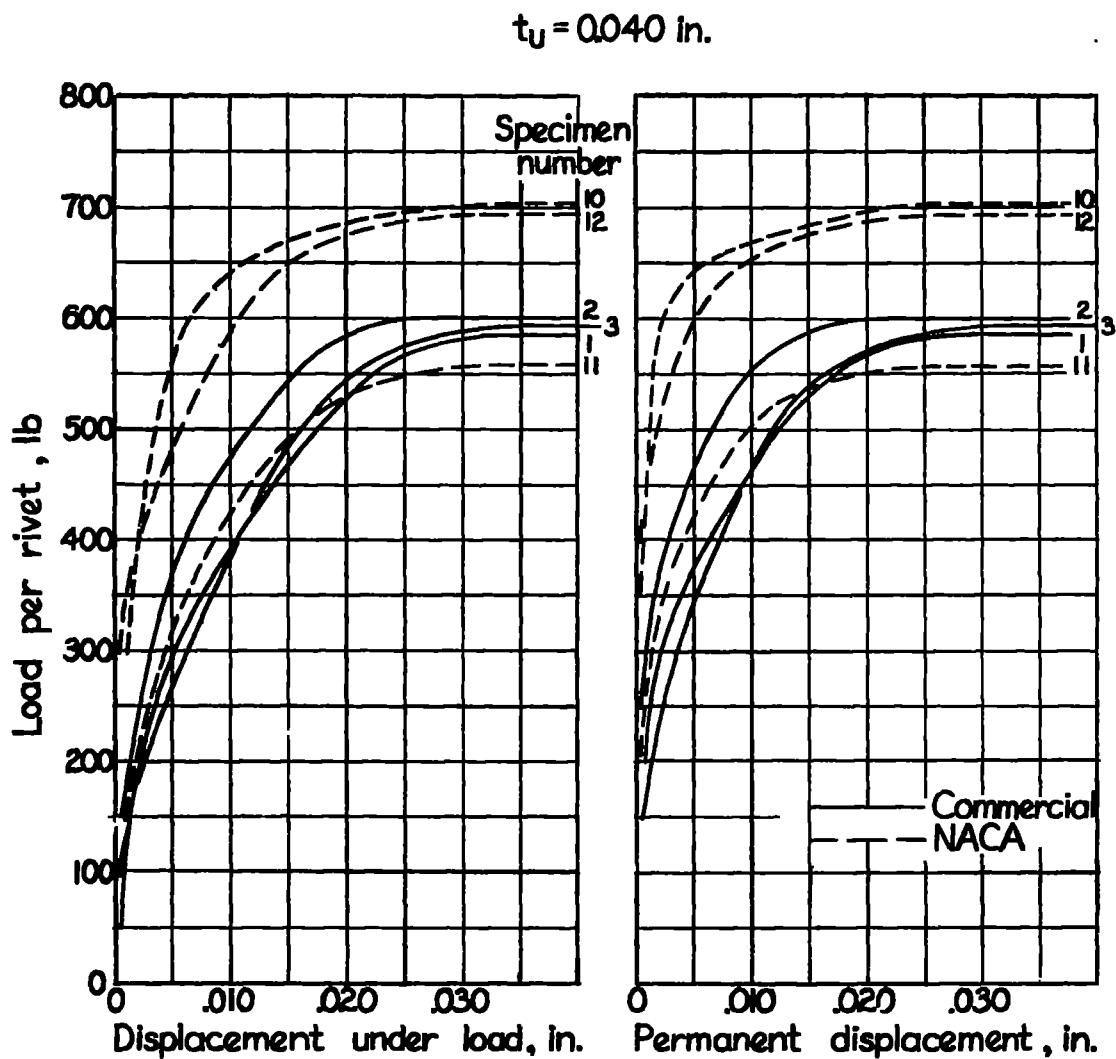


Figure 8.~ Load-displacement curves for commercial and NACA counterpunched flush-rivet specimens, $d = \frac{1}{8}$ in.

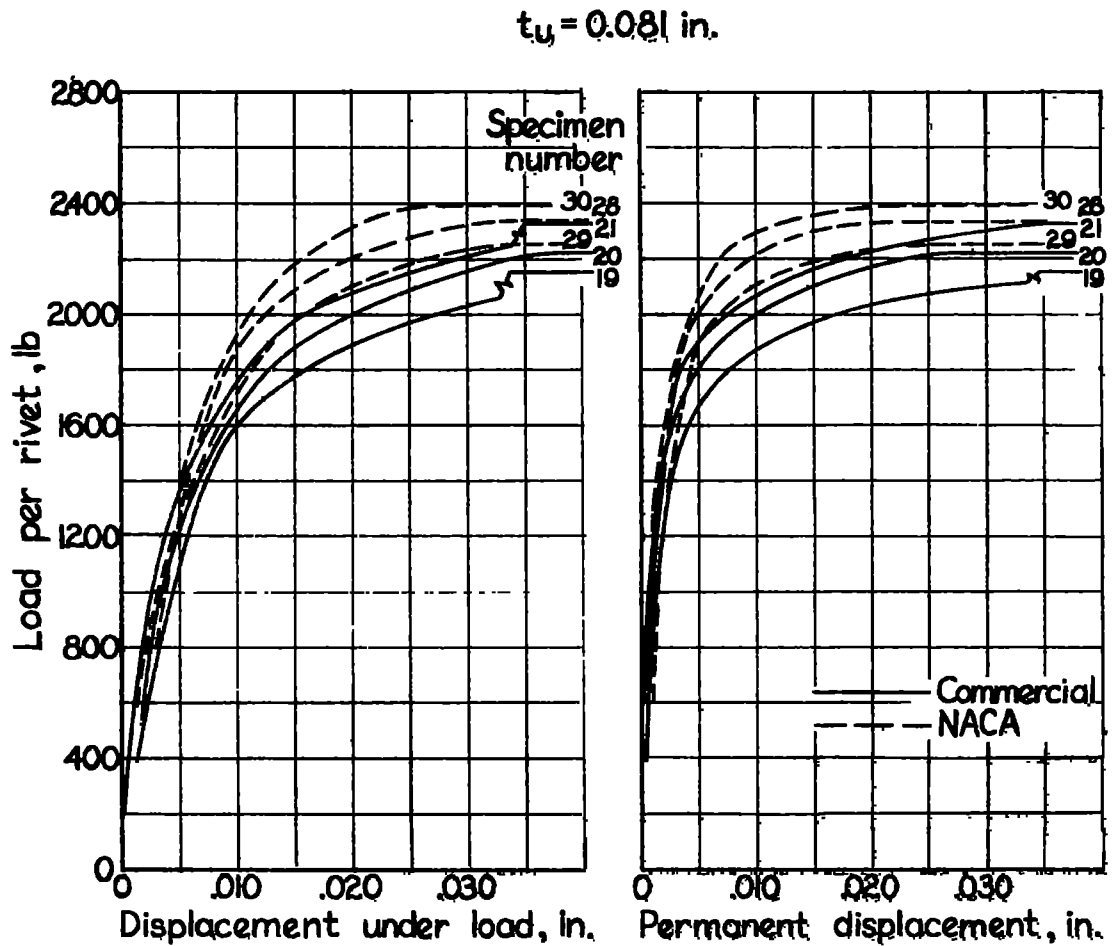


Figure 9. ~ Load-displacement curves for commercial and NACA counterpunched flush-rivet specimens, $d = \frac{1}{4}$ in.



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